

GSFC MO&DSD TECHNOLOGY DEVELOPMENT PLAN

TITLE: ONBOARD NAVIGATION SYSTEM IN A USER RECEIVER	
NASA UPN: 315-90-17-04	WORK AREA MANAGER: Cheryl Gramling
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BRIEF TECHNICAL SUMMARY (*Objectives and Approach*)

The Flight Dynamics Division is investigating numerous ways to reduce spacecraft ground operations support costs and provide increased capabilities to the user community. The potential for reducing spacecraft ground operations support costs can be realized by performing selected flight dynamics functions autonomously onboard a spacecraft.

Integrating the flight proven Onboard Navigation System (ONS) in a user receiver is one such development project. ONS in a user receiver will provide increased spacecraft autonomy and reduced ground operations support costs while significantly reducing spacecraft development, integration, and test cost and risk.

APPROVALS		
WORK AREA MANAGER:	DIVISION MANAGER:	GSFC PROGRAM MANAGER:

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JUSTIFICATION AND BENEFITS

Task 1 - Onboard Navigation System in a User Receiver

By measuring the Doppler of a forward link communication signal from a ground station to the user spacecraft and processing it in onboard flight software, the Onboard Navigation System (ONS) provides navigation products commensurate with those available from other state-of-the-art standalone navigation systems. ONS eliminates ground orbit determination operations costs for the user and, by placing the necessary navigation flight software in the user's receiver, ONS significantly reduces development, integration, and test costs and system risk for the user's navigation system. Through optimal and passive use of existing spacecraft communications systems, ONS can provide small satellite users with real-time, definitive position, velocity, frequency, and time maintenance, which can be directly propagated onboard to support the attitude subsystem, ground track data generation, autonomous signal acquisition, science annotation, and science planning.

Task 2 - Crosslink Navigation for Formation Flying

As a follow-on to ONS, the same concept can be applied to spacecraft flying in formation. The Doppler on a one-way spacecraft-to-spacecraft crosslink signal can be measured and processed onboard to provide relative navigation data of the transmitting spacecraft to the receiving spacecraft. Rather than relying on less accurate ground uplink ephemeris data, providing autonomous relative navigation data to the orbit control flight software achieves an enhanced level of autonomy for the entire constellation and allows for tighter formation boundaries/control boxes.

APPROACH AND PLAN

Task 1 - Onboard Navigation System in a User Receiver

Measuring Doppler on the received carrier can be a by-product of a digital receiver using a numerically controlled oscillator (NCO): accumulating the carrier tracking loop NCO offset provides a measure of the Doppler effect on the carrier. This has previously been accomplished in software. For high accuracy navigation products the receiver must be able to accept a stable oscillator as its reference frequency to provide high quality measurements. Users requiring less accuracy can use a less stable TCXO-type oscillator as the measurement reference. Onboard software is needed to process the observations in a sequential estimator either in real-time, or as required by the spacecraft.

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Use of ONS by small satellites requires a capability for Doppler measurement of the uplinked carrier. Some GN transponders on the market employ an analog implementation which may not provide clean Doppler data for navigation. A command receiver currently available extracts Doppler from an incoming TDRSS or GN signal. The receiver has been modified to include a synchronization circuit. Flying the modified command receiver along with a modified subset of the navigation flight software developed for the EOS-AM1 Project will provide operational navigation products to a small satellite, again proving the benefits of autonomous navigation using NASA communications systems. This task will complete the design of a navigation processor board for the Command Receiver to host the ONS algorithms. Following the final design, the navigation processor board will be fabricated.

After the data interfaces are defined, the EOS-AM1 flight software will be modified based on previously delivered Mathematical Specifications for ONS in a User Receiver. Then, the ONS in a User Receiver flight software will be hosted on the fabricated navigation processor board and tested. The final delivery is an engineering model command receiver with a Doppler extractor, synchronization circuit, and navigation processor board and ONS flight software - an integrated navigation package.

The command receiver is the mother design for Motorola's Fourth Generation Transponder and as such the navigation processor board design could carry over to the Fourth Gen as a user option.

Pursuit of a flight opportunity will culminate in flying ONS integrated in a receiver for operational autonomous navigation.

Future studies include an ONS for autonomous navigation by deep space missions. Using low dynamics forward-link Doppler observations and accurate attitude sensor data, ONS algorithms can be used to support autonomous navigation for deep-space, HEO, gravity-assist, or libration point orbits.

Task 2 - Crosslink Navigation for Formation Flying

As a new measurement type, capability does not currently exist to adequately simulate data for analysis. Therefore, the first step is to develop the measurement model and add it to both a software simulation tool (Navigation Processing System) and prototype flight software algorithms (Prototype Filter Smoother). Once simulated, analysis to determine data quality, data frequency, and ability to meet formation flying navigation knowledge constraints will be analyzed.

GSFC MO&DSD TECHNOLOGY DEVELOPMENT PLAN

UPN: 315-90-17-04: ONBOARD NAVIGATION SYSTEM IN A USER RECEIVER

As available, funding will be used to support measurement model modifications to the ONS flight software and to develop appropriate filter tuning parameters for the crosslink relative navigation environment.

DELIVERABLES

<u>ITEM</u>	<u>DATE</u>
Task 1 - Onboard Navigation System in a User Receiver	
a. Preliminary Design of Navigation Processor Board	02/97
b. Interface Definition	04/97
Task 2 - Crosslink Navigation for Formation Flying	
a. Complete Measurement Model	10/96
b. Modify Simulation Tool w/Measurement Model	11/96
c. Modify Prototype Algorithms w/Measurement Model	11/96
d. Complete Crosslink analysis for EO-1	01/97

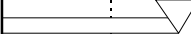
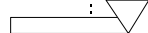

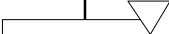


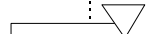


RESOURCE REQUIREMENTS

<u>Task Name</u>	<u>NASA UPN</u>	<u>FY97 (\$K)</u>	<u>FY98 (\$K)</u>	<u>FY99 (\$K)</u>	<u>FY00 (\$K)</u>	<u>FY01 (\$K)</u>	<u>FY02 (\$K)</u>
Onboard Navigation System In User Receiver	(315-90- 17-04)	100	150	150	150	150	150

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SCHEDULE

ONBOARD NAVIGATION SYSTEM IN A USER RECEIVER	FY97				FY98		FY99	FY00	FY01	FY02
	Q1	Q2	Q3	Q4	Q1/2	Q3/4				
<u>Task 1:</u> <u>Command Receiver Development</u> a. Nav Processor Board Pre. Design b. Nav Processor Board Crt. Design c. Nav Processor Board Fabrication d. Flight S/W Integration & Test e. Interface Definition f. Flight S/W Development g. Pursue Flight Opportunity/Launch										
<u>Task 2:</u> <u>Crosslink Navigation for Formation Flying</u> a. Add Measurement Model to Sim b. Add Measurement Model to Proto c. Crosslink Analysis Completed d. ONS FSW Relative Nav. Mods										
Resources by FY (\$K):	100				150		150	150	150	150